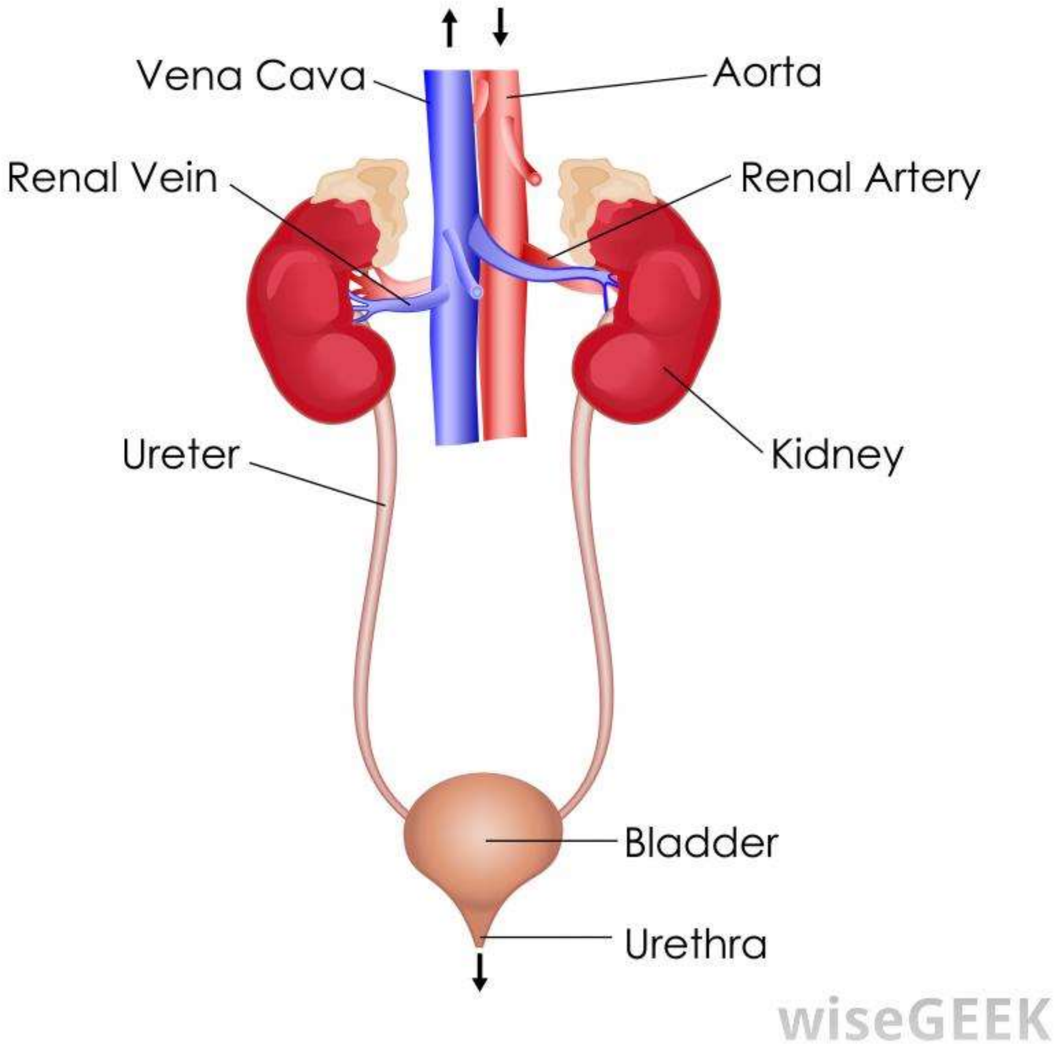
The excretory system

The excretory system is a passive biological system that removes excess, unnecessary materials from the body fluids of an organism, so as to help maintain internal chemical homeostasis and prevent damage to the body. The dual function of excretory systems is the elimination of the waste products of metabolism and to drain the body of used up and broken down components in a liquid and gaseous state. In humans and other amniotes (mammals, birds and reptiles) most of these substances leave the body as urine and to some degree exhalation, mammals also expel them through sweating.

Only the organs specifically used for the excretion are considered a part of the excretory system. In the narrow sense, the term refer to the urinary system. However, as excretion involves several functions that are only superficially related, it is not usually used in more formal classifications of anatomy or function.

As most healthy functioning organs produce metabolic and other wastes, the entire organism depends on the function of the system. Breaking down of one of more of the systems is a serious health condition, for example renal failure.

Parts and their functions:



Kidneys

The kidneys are bean-shaped organs which are present on each side of the vertebral column in the abdominal cavity. Humans have two kidneys and each kidney is supplied with blood from the renal artery. The kidneys remove from the blood the nitrogenous wastes such as urea, as well as salts and excess water, and excrete them in the form of urine. This is done with the help of millions of nephrons present in the kidney. The filtrated blood is carried away from the kidneys by the renal vein (or kidney vein). The urine from the kidney is collected by the ureter (or excretory tubes), one from each kidney, and is passed to the urinary bladder. The urinary bladder collects and stores the urine until urination. The urine collected in the bladder is passed into the external environment from the body through an opening called the urethra.

Liver

The liver detoxifies and breaks down chemicals, poisons and other toxins that enter the body. For example, the liver transforms ammonia (which is poisonous) into urea in fish, amphibians and mammals, and into uric acid in birds and reptiles. Urea is filtered by the kidney into urine or through the gills in fish and tadpoles. Uric acid is paste-like and expelled as a semi-solid waste (the "white" in bird excrements). The liver also produces bile, and the body uses bile to break down fats into usable fats and unusable waste.

Invertebrates lack a liver, but most terrestrial groups, like insects, possesses a number of blind guts that serve the similar functions. Marine invertebrates do not need the ammonia conversion of the liver, as they can usually expel ammonia directly by diffusion through the skin.

Bile

After bile is produced in the liver, it is stored in the gall bladder. It is then secreted within the small intestine where it helps to break down ethanol, fats and other acidic wastes including ammonia, into harmless substances.

Large intestine

The large intestine's main function is to transport food particles through the body and expel the indigestible parts at the other end, but it also collects waste from throughout the body. The typical brown colour of mammal waste is due to billirubin, a breakdown product of normal heme catabolism.[1] The lower part of the large intestine also extracts any remaining usable water and then removes solid waste. At about 10 feet long in humans, it transports the wastes through the tubes to be excreted.

Skin

In mammals. the skin excretes sweat through sweat glands throughout the body. The sweat, helped by salt, evaporates and helps to keep the body cool when it is warm. In amphibians, the lungs are very simple, and they lack the necessary means to the exhale like other tetrapods can. The moist, scale-less skin is therefore essential in helping to rid the blood of carbon dioxide (on the form of carbolic acid), and also allows for urea to be expelled through diffusion when submerged.

In small-bodied marine invertebrates, the skin is the most important excretory organ. That is particularly true for acoelomate groups like cnidarians, flatworms and nemerteans, who have no body cavities and hence no body fluid that can be drained or purified by nephrons, which is the reason acoelomate animals are thread-like (nemertans), flat (flatworms) or only consist of a thin layer of cells around a gelatinous non-cellular interior (cnidarians).

Eccrine

Like sweat glands, eccrine glands allow excess water to leave the body. The majority of eccerine glands are located mainly on the forehead, the bottoms of the feet, and the palms, although the glands are everywhere throughout the body. They help the body to maintain temperature control. Eccrine glands in the skin are unique to mammals.

Component organs

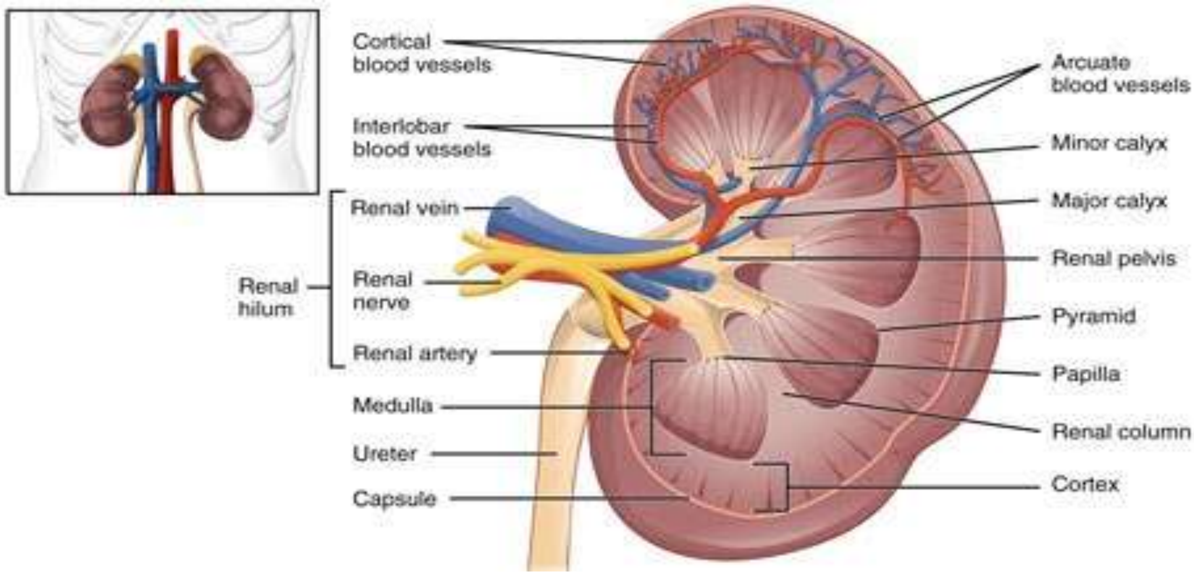
Skin

Sweat glands in the skin secrete a fluid waste called sweat or perspiration; however, its primary functions are temperature control and pheromone release. Therefore, its role as a part of the excretory system is minimal. Sweating also maintains the level of salt in the body.

Lungs

One of the main functions of the lungs is to diffuse gaseous wastes, such as carbon dioxide, from the bloodstream as a normal part of respiration.

Kidneys



The kidney's primary function is the elimination of waste from the bloodstream by production of urine. They perform several homeostatic functions such as-:

1. Maintain volume of extracellular fluid
2. Maintain ionic balance in extracellular fluid
3. Maintain pH and osmotic concentration of the extracellular fluid.
4. Excrete toxic metabolic by-products such as urea, ammonia, and uric acid.

The way the kidneys do this is with nephrons. There are over 1 million nephrons in each kidney; these nephrons act as filters inside the kidneys. The kidneys filter needed materials and waste, the needed materials go back into the bloodstream, and unneeded materials becomes urine and is gotten rid of.

In some cases, excess wastes crystallize as kidney stones. They grow and can become painful irritants that may require surgery or ultrasound treatments. Some stones are small enough to be forced into the urethra.

Ureter

The ureters are muscular ducts that propel urine from the kidneys to the urinary bladder. In the human adult, the ureters are usually 25–30 cm

(10–12 in) long. In humans, the ureters arise from the renal pelvis on the medial aspect of each kidney before descending towards the bladder on the front of the psoas major muscle. The ureters cross the pelvic brim near the bifurcation of the iliac arteries (which they run over). This "pelviureteric junction" is a common site for the impaction of kidney stones (the other being the uteterovesical valve). The ureters run posteriorly on the lateral walls of the pelvis. They then curve anteriormedially to enter the bladder through the back, at the vesicoureteric junction, running within the wall of the bladder for a few centimeters. The backflow of urine is prevented by valves known as ureterovesical valves. In the female, the ureters pass through the mesometrium on the way to the bladder.

Urinary bladder

The urinary bladder is the organ that collects waste excreted by the kidneys prior to disposal by urination. It is a hollow muscular, and distensible (or elastic) organ, and sits on the pelvic floor. Urine enters the bladder via the ureters and exits via the urethra.

Embryologically, the bladder is derived from the urogenital sinus, and it is initially continuous with the allantois. In human males, the base of the bladder lies between the rectum and the pubic symphysis. It is superior to the prostate, and separated from the rectum by the rectovesical excavation. In females, the bladder sits inferior to the uterus and anterior to the vagina. It is separated from the uterus by the vesicouterine excavation. In infants and young children, the urinary bladder is in the abdomen even when empty.

Urethra

In anatomy, the (from Greek - ourethra) is a tube which connects the urinary bladder to the outside of the body. In humans, the urethra has an excretory function in both genders to pass.

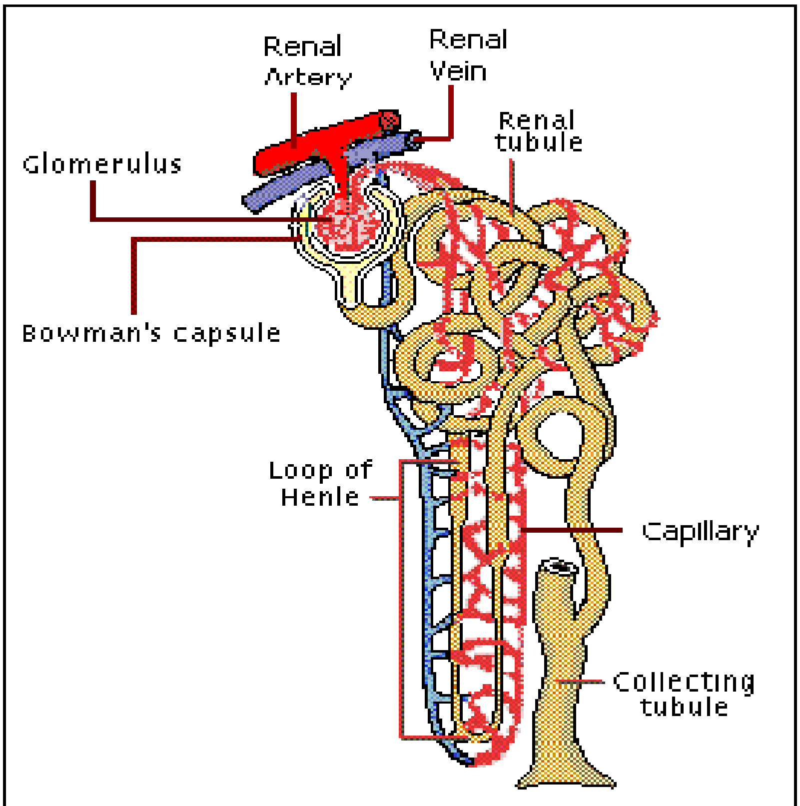
The Process of Urine Formation

Urine formation is a very sophisticated process that takes place in the kidneys. This important process provides a mechanism for the body to get rid of metabolic wastes and toxins, which can be deadly if allowed to accumulate in the body. The kidneys have the very important responsibility for extracting toxins and other waste products from the blood. Blood performs many crucial functions within the body and is largely responsible for sustaining health and life. In addition to defending the body against diseases, blood is also responsible for transporting oxygen, hormones and other essential nutrients around the body. It is, therefore, important that blood consistently has the correct chemical composition and is free of wastes and toxins, which can be dangerous to the body. Maintaining the correct volume and concentration of blood and removing wastes and toxins from it are essential functions of the kidneys. The kidneys are able to do this by converting unwanted blood plasma into urine and expelling it from the body.

If the process of urine formation is disrupted or inhibited, over an extended period of time, toxins begin to accumulate in the body and this can cause quite serious medical conditions and eventually results in death. Basically, the process of urine formation takes place in three (3) stages, as blood plasma flows through the nephrons. Nephrons are microscopic tube-like structures in the kidneys that filter the blood and cause wastes to be removed. They are the most basic structures of the kidney's anatomy. Each kidney contains over one million nephrons. As the blood plasma flow through the nephrons, its composition changes. Fluids comprising excess water, salt and metabolic waste products are extracted from the blood as it enters the Bowman's capsule in the nephrons.

1. This fluid in the in the Bowman's capsule is called glomerular filtrate. It is similar to blood plasma except that it has almost no protein.

2. As the fluid moves through the renal tubule it is called tubular fluid. It is different form glomerular filtrate because of substances which are removed and added by the tubule cells.
3. Finally, when the fluid moves into the collecting tubule it is called urine.



Nephron

Stage 1 of Urine Formation: GLOMERULAR FILTRATION

Glomerular filtration is a process in which water and some other substances in the blood plasma pass from the capillaries of the glomerulus into the Bowman's capsule. Very small molecules can pass through the filtration membrane into the Bowman's capsule. This includes water, electrolytes, glucose, fatty acids, amino acids, nitrogenous wastes, and vitamins.

These substances have about the same concentration in the glomerular filtrate (fluid in the in the Bowman's capsule) as in the blood plasma. Some substances are retained in the bloodstream because they are bound to plasma proteins that cannot get through the membrane. For example, most calcium, iron, and thyroid hormone in the blood are bound to plasma proteins that retard their filtration by the kidneys. The small fractions that are not bound to plasma protein, however, passes freely through the filtration membrane and appears in the urine.

Kidney infection and trauma can damage the filtration membrane (located in the Bowman's capsule). This allows albumin (a protein) or blood cells to filter through. Kidney disease can sometimes be detected by the presence of protein (especially albumin) or blood in the urine. The medical terms for the presence of protein and blood in the urine are proteinuria (albuminuria) and hematuria, respectively.

Glomerular filtration must be precisely controlled. If it is too high, fluid flows through the renal tubules too rapidly for them to reabsorb the required amount of water and solutes. If it is too low, fluid flows too slowly through the tubules and wastes that should be eliminated are reabsorbed into the bloodstream. Renal autoregulation is the ability of the nephrons to adjust their own blood flow. It allows them to maintain a relatively stable glomerular filtration rate in spite of changes in arterial blood pressure.

Stage 2: TUBULAR REABSORPTION AND SECRETION

The second stage of urine formation is tubular reabsorption and secretion. This involves removal and addition of chemicals, after glomerular filtrate leaves the Bowman's capsule and enters the renal tubule. The Renal tubule is very long, which increases its absorptive surface area. It reabsorbs about 65% of the glomerular filtrate, while it removes some substances from the blood.

Tubular reabsorption is the process of reclaiming water and other substances from the tubular fluid (glomerular filtrate which passes from the Bowman's capsule to the renal tubule) and returning them to the blood.

- Sodium reabsorption is the key to everything else. It creates the environment for water and other substances to be reabsorbed. Glucose is transported along with sodium irons by carriers called sodium-glucose transport proteins. Normally all glucose in the tubular fluid is reabsorbed and there is none in the urine.
- Water reabsorption is a significant function of the kidney. The amount of water reabsorption is continually regulated by hormones according to the body's state of hydration. The more hydrated the body, the less water is reabsorbed, and vice versa.
- Nitrogenous wastes such as urea diffuses through the renal tubule with water. The kidneys remove about 50% of the urea in the blood thus keeping its concentration down to a safe level, but not completely clearing the blood of it. Almost all uric acid is first reabsorbed by the renal tubule but later parts of the nephron secretes it back into the tubular fluid. Creatinine is not reabsorbed at all. It is too large to diffuse through water channels in the plasma membrane, and there are no transport proteins for it. All creatinine filtered by the glomerulus is, therefore, excreted in the urine.

After water and other substances leave the surface of the renal tubule, they are reabsorbed by the capillaries, into the bloodstream.

Tubular secretion is the process in which renal tubule extracts chemicals from the capillary's blood and secretes them into the tubular fluid. This process serves two main purposes:

1. Waste removal. Urea, uric acid, bile acids, ammonia, and creatinine are secreted into the renal tubule. Tubular secretion clears the blood of pollutants and drugs as well. One reason why so many drugs (prescription drugs) must be taken three to four times per day is to maintain the therapeutically effective drug concentration in the blood, to compensate for the rate of clearance, through tubular secretion.
2. Maintaining the acid-base balance. Tubular secretion of hydrogen and bicarbonate irons serves to regulate the pH of the body's fluids.

Stage 3 of Urine Formation: WATER CONSERVATION

The third and final stage of urine formation is water conservation. The kidneys are not only responsible for eliminating metabolic wastes from the body but they also prevent excessive water loss, in doing so. This is very important in maintaining the body's fluid balance. Urine is made up mostly of water. It plays a significant role in the entire process of waste elimination. If, however, too much water is removed from the body, it results in dehydration, which could lead to other serious medical conditions.

When tubular fluid leaves the renal tubule it goes to the collecting tubule (or collecting duct). At this stage the tubular fluid becomes urine. The renal tubule of several nephrons drain into the collecting tubule. This results in a significant amount of water being drained into the collecting tubule. If all this water was eliminated, it would amount to about 36 liters of urine per day. One can only imagine the devastating effects this would have on the body as this far exceeds the average volume of urine excreted by an adult, of 1 to 2 liters per day.

The collecting tubule receives tubular fluid from numerous nephrons. As it moves along the collecting tubule it become more and more concentrated. This causes water to be reabsorbed into the bloodstream, by the process of osmosis.

The relative concentration of the urine depends on the body's state of hydration. For example, if you drink a large volume of water, you will produce a large volume of urine which is less concentrated. On the other hand if you are dehydrated, your urine is much more concentrated and the volume is much lower. The collecting duct can adjust water reabsorption, depending on the body's need for water conservation or removal.

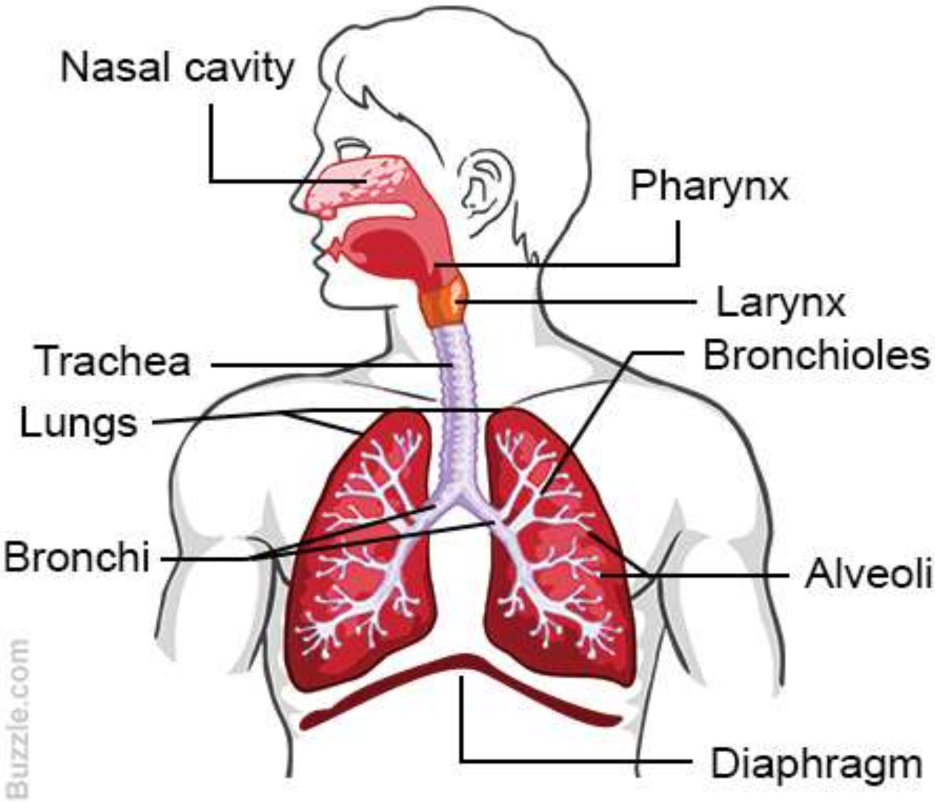
Urine formation is essential for maintaining Homeostasis (ho-me-oh-stay-sis), which is the ability of the body to maintain internal stability. For this reason, some medical diagnosis and evaluation of renal function are based on urine analysis. Urinalysis (the examination of physical and chemical properties of urine) is, therefore, one of the most routine procedures in medical examinations.

The respiratory system

The respiratory system (called also respiratory apparatus, ventilatory system) is a biological system consisting of specific organs and structures used for the process of respiration in an organism. The respiratory system is involved in the intake and exchange of oxygen and carbon dioxide between an organism and the environment.

In air-breathing vertebrates like human beings, respiration takes place in the respiratory organs called lungs. The passage of air into the lungs to supply the body with oxygen is known as inhalation, and the passage of air out of the lungs to expel carbon dioxide is known as exhalation; this process is collectively called breathing or ventilation. In humans and other mammals, the anatomical features of the respiratory system include trachea, bronchi, bronchioles, lungs, and diaphragm. Molecules of oxygen and carbon dioxide are passively exchanged, by diffusion, between the gaseous external environment and the blood. This exchange process occurs in the alveoli (air sacs) in the lungs.

In fish and many invertebrates, respiration takes place through the gills. Other animals, such as insects, have respiratory systems with very simple anatomical features, and in amphibians even the skin plays a vital role in gas exchange. Plants also have respiratory systems but the directionality of gas exchange can be opposite to that in animals. The respiratory system in plants also includes anatomical features such as holes on the undersides of leaves known as stomata.



Parts of the respiratory system

As we breathe, oxygen enters the nose or mouth and passes the sinuses, which are hollow spaces in the skull. Sinuses help regulate the temperature and humidity of the air we breathe.

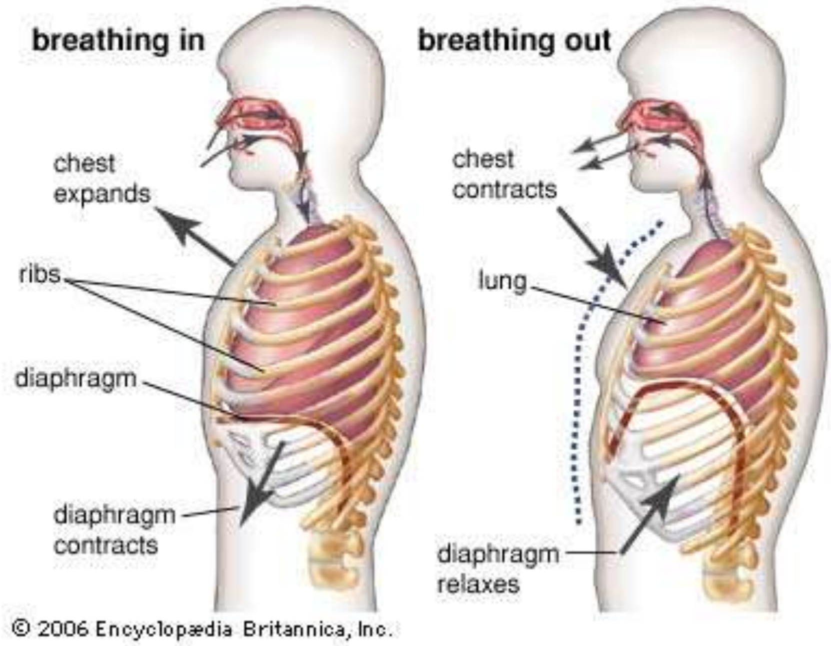
The trachea, also called the windpipe, filters the air that is inhaled, according to the American Lung Association. It branches into the bronchi, which are two tubes that carry air into each lung. The bronchial tubes are lined with tiny hairs called cilia. Cilia move back and forth, carrying mucus up and out. Mucus, a sticky fluid, collects dust, germs and other matter that has invaded the lungs. We expel mucus when we sneeze, cough, spit or swallow.

The bronchial tubes lead to the lobes of the lungs. The right lung has three lobes; the left lung has two, according to the American Lung Association. The left lung is smaller to allow room for the heart, according to the National Heart, Lung and Blood Institute (NHLBI). Lobes are filled with small, spongy sacs called alveoli, and this is where the exchange of oxygen and carbon dioxide occurs .

The alveolar walls are extremely thin (about 0.2 micrometers). These walls are composed of a single layer of tissues called epithelial cells and tiny blood vessels called pulmonary capillaries.

Blood passes through the capillaries. The pulmonary artery carries blood containing carbon dioxide to the air sacs, where the gas moves from the blood to the air, according to the NHLBI. Oxygenated blood goes to the heart through the pulmonary vein, and the heart pumps it throughout the body.

The diaphragm, a dome-shaped muscle at the bottom of the lungs, controls breathing and separates the chest cavity from the abdominal cavity, the American Lung Association noted. When a breath it taken, it flattens out and pulls forward, making more space for the lungs. During exhalation, the diaphragm expands and forces air out.



Mechanics of Inhalation and exhalation

In mammals, breathing in (inhalation) at rest is primarily due to the contraction and flattening of the diaphragm, a domed muscle that separates the thoracic cavity from the abdominal cavity. When the diaphragm contracts it pushes the abdominal organs downward, but since the pelvic floor prevents the lowermost abdominal organs from moving in that direction, the abdomen, in fact, bulges forwards (or outwards). In the process the size of the thoracic cavity has increased in volume (as has the volume of the body as a whole). This increased thoracic volume results in a fall in pressure in the thorax, which causes the expansion of the lungs. During exhalation (breathing out), at rest, the diaphragm relaxes, returning the chest and abdomen to a position which is determined by their anatomical elasticity (i.e. the position in the cadaver, or in an animal that has been given a muscle relaxant under anesthesia). This is the "resting mid-position" of the thorax when the lungs contain the functional residual capacity of air, which in the adult human has a volume of about 2.5 liters.[12] Resting exhalation lasts about twice as long as inhalation because the diaphragm relaxes more gently than it contracts during inhalation. This prevents undue narrowing of the airways, from which the air escapes more easily than from the alveoli.

During heavy breathing (hyperventilation), as, for instance, during exercise, the "accessory muscles of inhalation" (of which the first to be recruited are the intercostal muscles, but include a large number of other muscles - see below) pull the ribs upwards, both in the front and on the sides. This increases the volume of the rib cage, adding to the volume increase caused by the descending diaphragm. During the ensuing exhalation the rib cage is actively pulled downwards (front and sides) by the abdominal muscles, which not only decreases the size of the rib cage, but also pushes the abdominal organs upwards against the diaphragm which consequently bulges deeply into the thorax. The end-exhalatory lung volume is now well below the resting mid-position and contains far less air than the resting "functional residual capacity". However, in a normal mammal, the lungs cannot be emptied completely. In an adult human there is always still at least 1 liter of residual air left in the lungs after maximum exhalation.

The entirely unconscious and automatic breathing on which the life of the animal depends can be temporarily over-ridden by conscious or emotion-driven movements of air in and out of the lungs. Speech in humans is generated by a specialized form of exhalation, but other forms of communication (e.g. crying, yelping, yawning, barking, baying, hissing, panting, sighing, shouting, laughing etc.) also rely on a balance between breathing for blood gas homeostasis and the emotional or other messages that need to be conveyed to the animal's conspecifics.

Ten muscles can be used for inhalation;
Diaphragm, Intercostal Muscles, Scalenes, Pectoralis Minor, Serratus Anterior, Sternocleidomastoid, Levator Costarum, Upper / Superior Trapezius, Latissimus Dorsi, and Subclavius.

Eight are used for forced exhalation;
Internal intercostal, Obliquus Internus, Obliquus Externus, Levator Ani, Triangularis Sterni, Transversalis, Pyramidalis, and Rectus Abdominus.